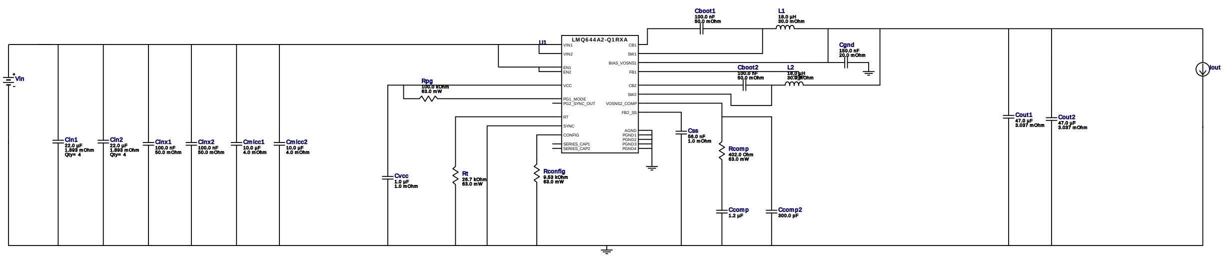
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 4.0V
VinMax = 16.0V
Vout = 3.3V
Iout = 2.0A

Device = LMQ644A2QRXARQ1
Topology = Buck
Created = 2024-09-08 15:44:55.151
BOM Cost = $12.51
BOM Count = 28
Total Pd = 0.14W

Design : 5 LMQ644A2QRXARQ1
LMQ644A2QRXARQ1 4V-16V to 3.30V @ 2A



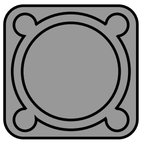
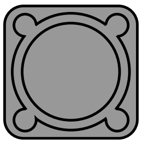
Design Alerts

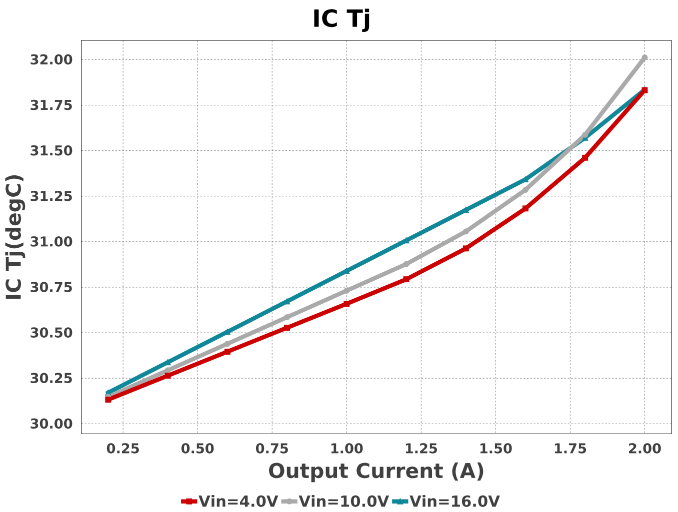
Component Selection Information

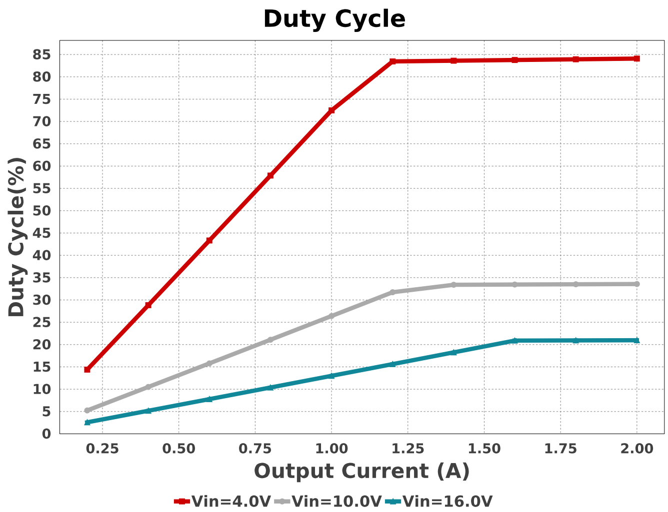
The LMQ644A2-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application

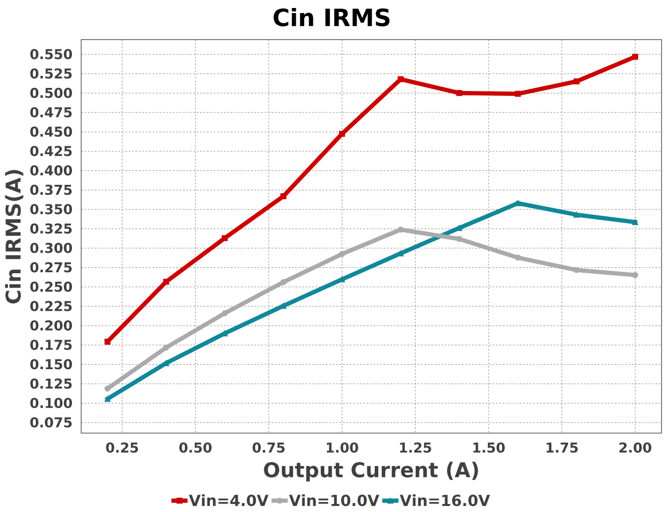
Electrical BOM

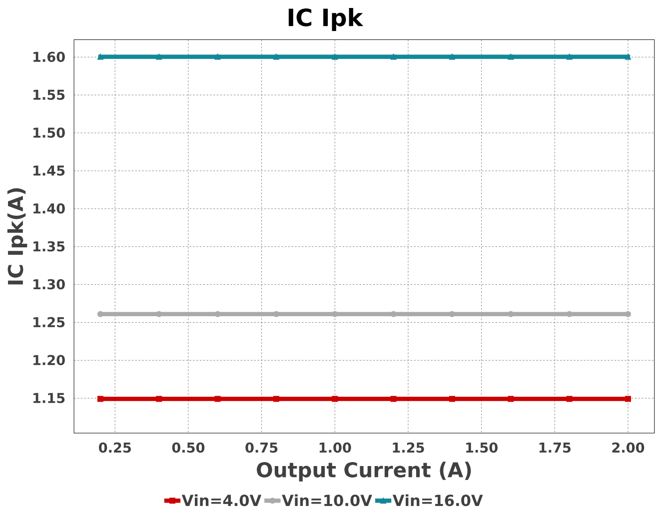
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot1	AVX	06033C104KAT2A Series= X7R	Cap= 100.0 nF ESR= 50.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Cboot2	AVX	06033C104KAT2A Series= X7R	Cap= 100.0 nF ESR= 50.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Ccomp	AVX	2225PC125MAT1A Series= X7R	Cap= 1.2 uF VDC= 250.0 V IRMS= 0.0 A	1	$0.34	2225 64 mm²
Ccomp2	Samsung Electro-Mechanics	CL10C301JB8NNNC Series= C0G/NP0	Cap= 300.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Cgnd	MuRata	GRM188R71E154KA01D Series= X7R	Cap= 150.0 nF ESR= 20.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.03	0603 5 mm²
Cin1	TDK	CGA9P2X7R1E226M250KA Series= X7R	Cap= 22.0 uF ESR= 1.893 mOhm VDC= 25.0 V IRMS= 6.635 A	4	$0.93	2220_280 54 mm²
Cin2	TDK	CGA9P2X7R1E226M250KA Series= X7R	Cap= 22.0 uF ESR= 1.893 mOhm VDC= 25.0 V IRMS= 6.635 A	4	$0.93	2220_280 54 mm²
Cinx1	AVX	06033C104KAT2A Series= X7R	Cap= 100.0 nF ESR= 50.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Cinx2	AVX	06033C104KAT2A Series= X7R	Cap= 100.0 nF ESR= 50.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²

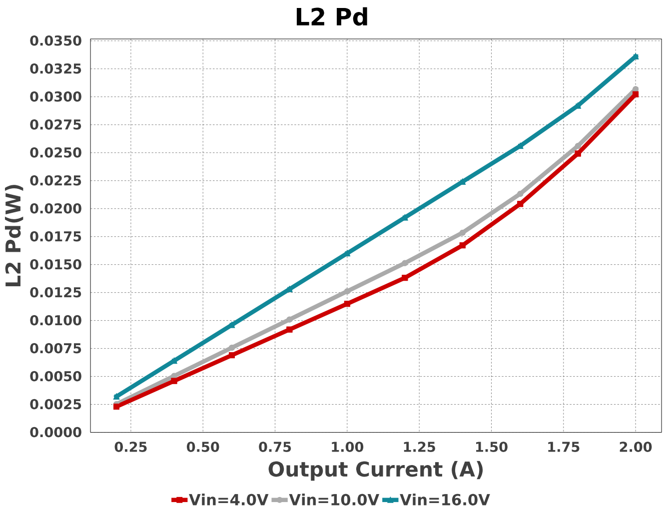
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cmlcc1	MuRata	GRM21BR61E106MA73L Series= X5R	Cap= 10.0 uF ESR= 4.0 mOhm VDC= 25.0 V IRMS= 2.8 A	1	$0.04	0805 7 mm^2
Cmlcc2	MuRata	GRM21BR61E106MA73L Series= X5R	Cap= 10.0 uF ESR= 4.0 mOhm VDC= 25.0 V IRMS= 2.8 A	1	$0.04	0805 7 mm^2
Cout1	MuRata	GRM32ER61C476KE15L Series= X5R	Cap= 47.0 uF ESR= 3.037 mOhm VDC= 16.0 V IRMS= 4.59346 A	1	$0.17	1210_280 15 mm^2
Cout2	MuRata	GRM32ER61C476KE15L Series= X5R	Cap= 47.0 uF ESR= 3.037 mOhm VDC= 16.0 V IRMS= 4.59346 A	1	$0.17	1210_280 15 mm^2
Css	MuRata	GRM188R71C563KA01D Series= X7R	Cap= 56.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.02	0603 5 mm^2
Cvcc	Kemet	C0603C105Z8VACTU Series= Y5V	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2
L1	Coilcraft	MSS1260-183MLB	L= 18.0 µH 30.0 mOhm	1	$0.68	 MSS1260 204 mm^2
L2	Coilcraft	MSS1260-183MLB	L= 18.0 µH 30.0 mOhm	1	$0.68	 MSS1260 204 mm^2
Rcomp	Vishay-Dale	CRCW0402402RFKED Series= CRCW..e3	Res= 402.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rconfig	Vishay-Dale	CRCW04029K53FKED Series= CRCW..e3	Res= 9.53 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rpg	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rt	Vishay-Dale	CRCW040226K7FKED Series= CRCW..e3	Res= 26.7 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
U1	Texas Instruments	LMQ644A2QRXARQ1	Switcher	1	$2.80	RXA0024A-MFG 51 mm^2

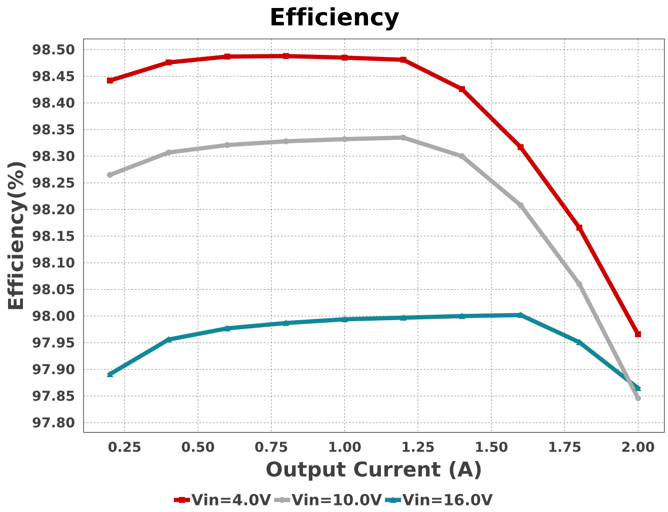

IC Tj
IC Tj(degC)
Output Current (A)
Vin=4.0V
Vin=10.0V
Vin=16.0V


Duty Cycle
Duty Cycle(%)
Output Current (A)
Vin=4.0V
Vin=10.0V
Vin=16.0V

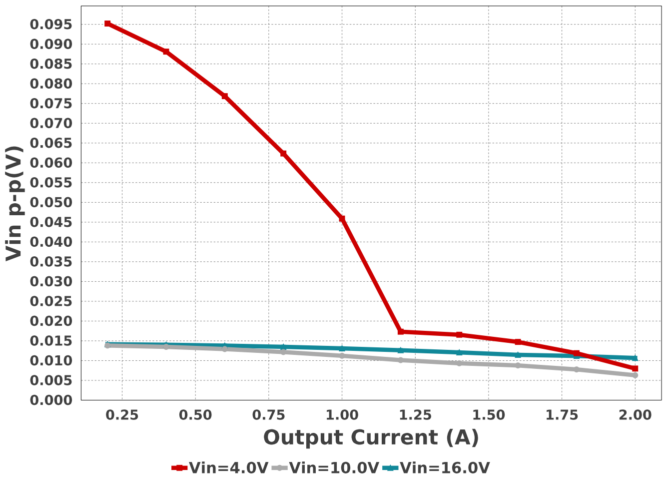

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=4.0V
Vin=10.0V
Vin=16.0V


IC Ipk
IC Ipk(A)
Output Current (A)
Vin=4.0V
Vin=10.0V
Vin=16.0V

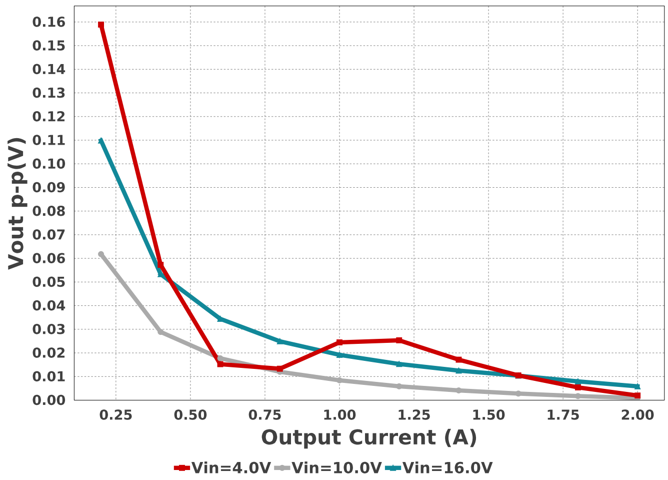

L2 Pd
L2 Pd(W)
Output Current (A)
Vin=4.0V
Vin=10.0V
Vin=16.0V


Efficiency
Efficiency(%)
Output Current (A)
Vin=4.0V
Vin=10.0V
Vin=16.0V

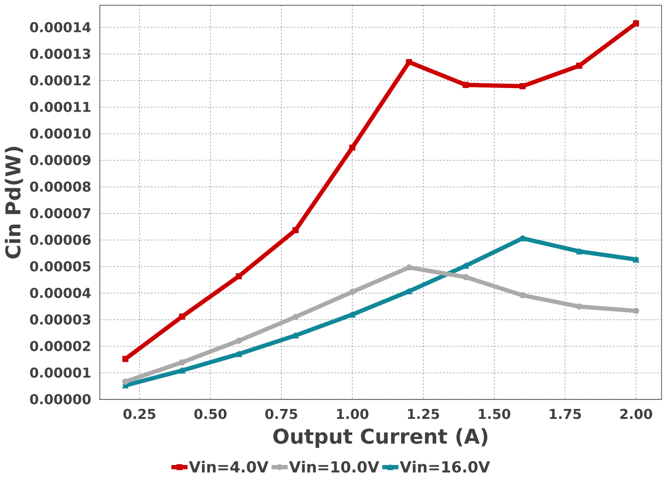
Vin p-p



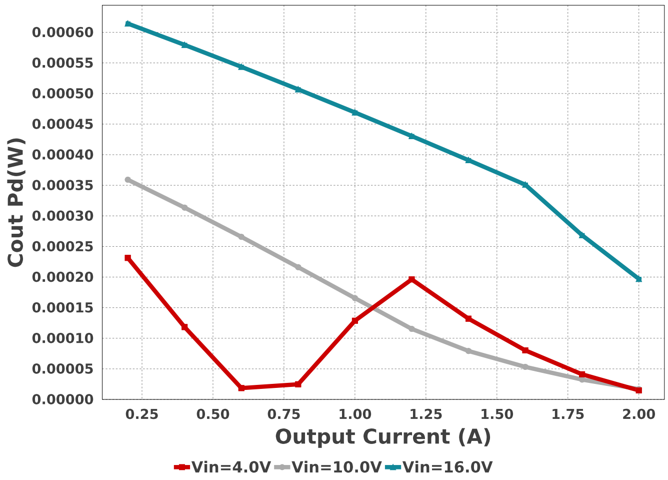
Vout p-p



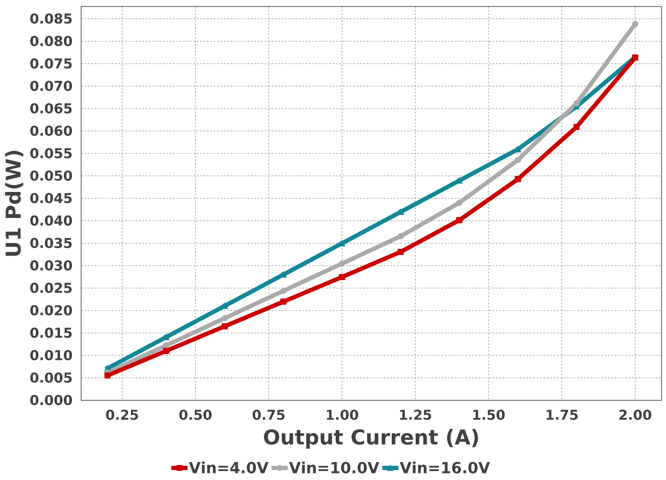
Cin Pd



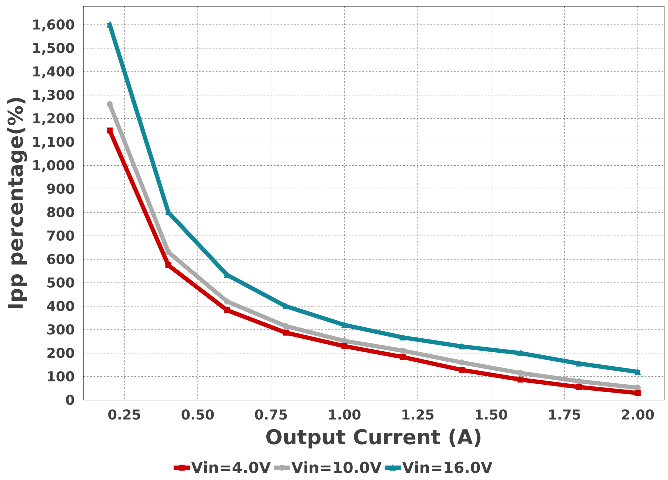
Cout Pd

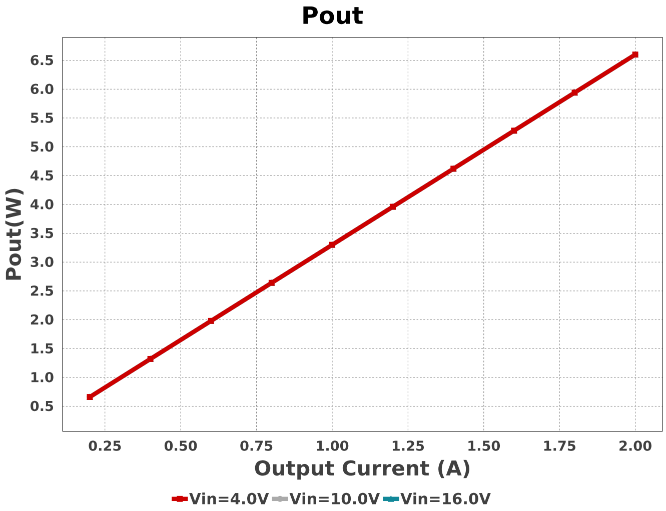


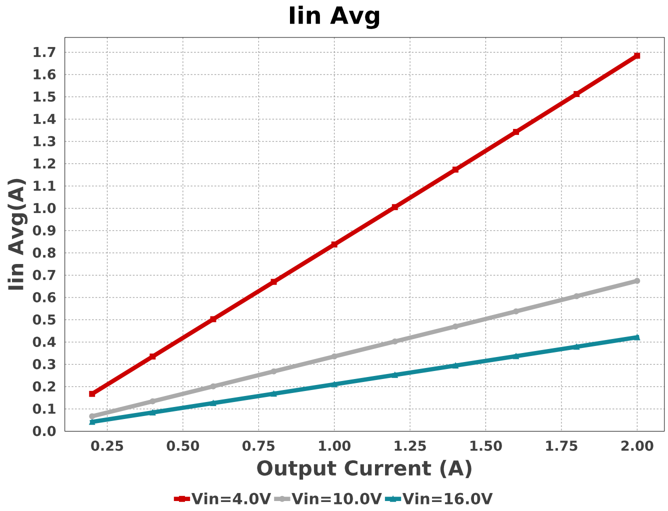
U1 Pd

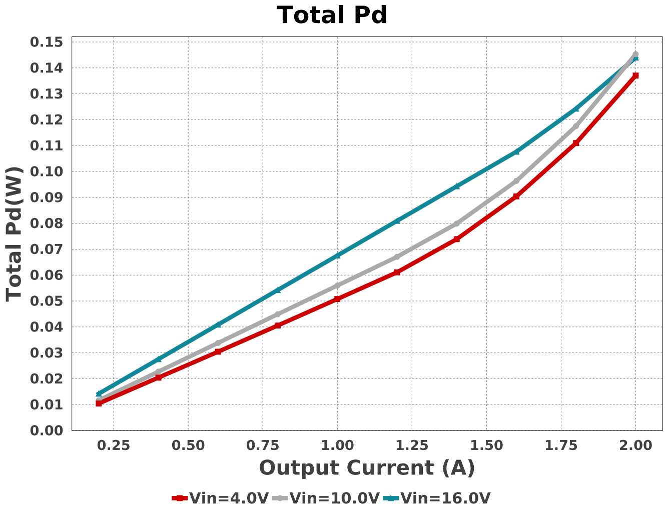


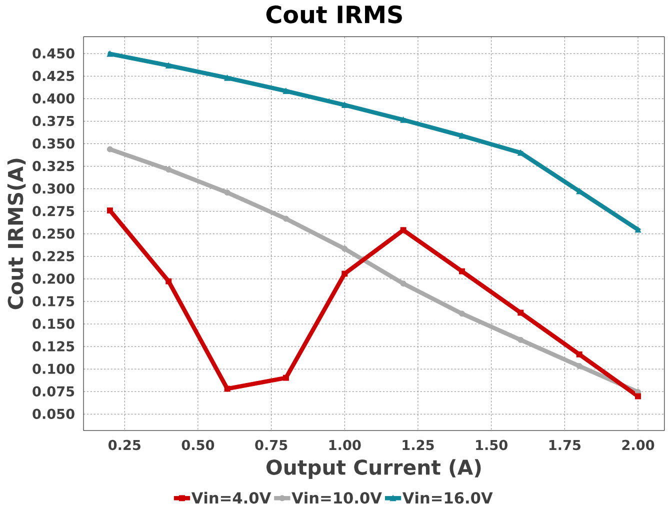
Ipp percentage

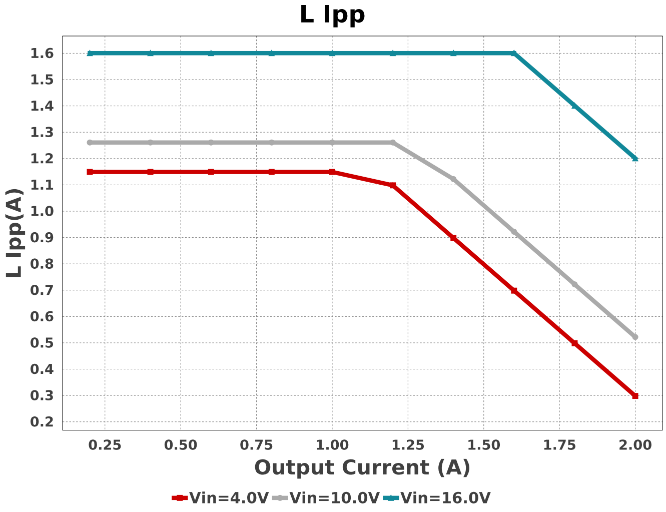


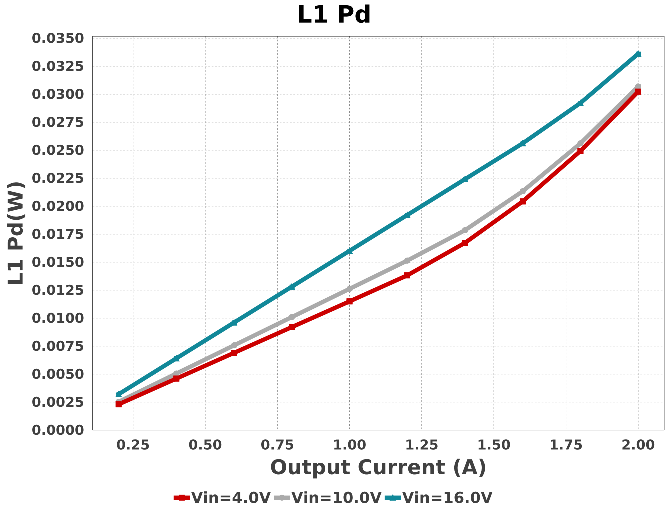

Pout
Pout(W)
Output Current (A)
Vin=4.0V Vin=10.0V Vin=16.0V

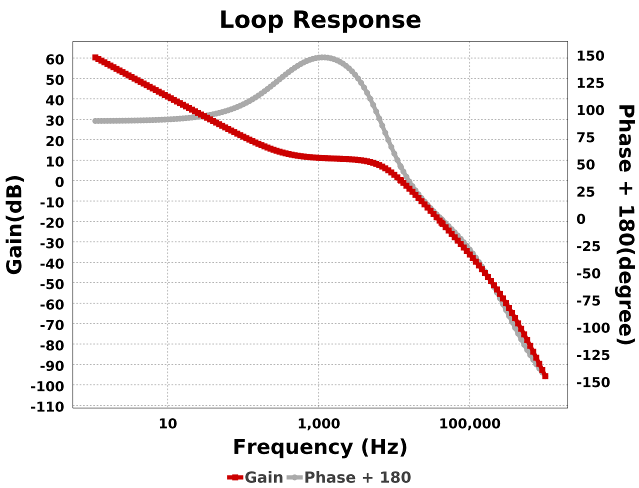

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=4.0V Vin=10.0V Vin=16.0V

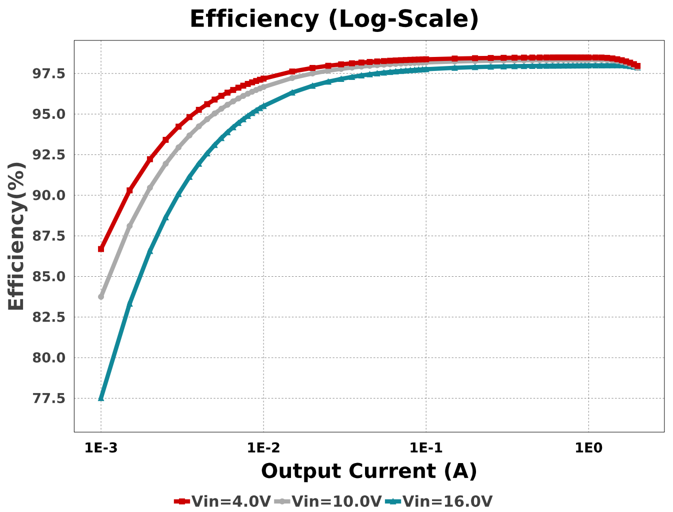

Total Pd
Total Pd(W)
Output Current (A)
Vin=4.0V Vin=10.0V Vin=16.0V


Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=4.0V Vin=10.0V Vin=16.0V


L Ipp
L Ipp(A)
Output Current (A)
Vin=4.0V Vin=10.0V Vin=16.0V


L1 Pd
L1 Pd(W)
Output Current (A)
Vin=4.0V Vin=10.0V Vin=16.0V





Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	333.581 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	52.662 µW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	254.669 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	196.97 µW	Capacitor	Output capacitor power dissipation
5.	IC Ipk	1.6 A	IC	Peak switch current in IC
6.	IC Tj	31.835 degC	IC	IC junction temperature
7.	ICThetaJA Effective	24.0 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
8.	Iin Avg	421.5 mA	IC	Average input current
9.	U1 Pd	76.467 mW	IC	IC power dissipation
10.	Ipp percentage	120.084 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
11.	L Ipp	1.201 A	Inductor	Peak-to-peak inductor ripple current
12.	L1 Pd	33.605 mW	Inductor	Inductor power dissipation
13.	L2 Pd	33.605 mW	Inductor	Inductor power dissipation
14.	Cin Pd	52.662 µW	Power	Input capacitor power dissipation
15.	Cout Pd	196.97 µW	Power	Output capacitor power dissipation
16.	L1 Pd	33.605 mW	Power	Inductor power dissipation
17.	L2 Pd	33.605 mW	Power	Inductor power dissipation
18.	Total Pd	143.984 mW	Power	Total Power Dissipation
19.	U1 Pd	76.467 mW	Power	IC power dissipation
20.	BOM Count	28	System Information	Total Design BOM count
21.	Duty Cycle	20.97 %	System Information	Duty cycle
22.	Efficiency	97.865 %	System Information	Steady state efficiency
23.	FootPrint	1.047 k mm^2	System Information	Total Foot Print Area of BOM components
24.	Frequency	122.576 kHz	System Information	Switching frequency
25.	Iout	2.0 A	System Information	Iout operating point
26.	Mode	PFM	System Information	Conduction Mode
27.	Pout	6.6 W	System Information	Total output power
28.	Total BOM	$12.51	System Information	Total BOM Cost
29.	Vin	16.0 V	System Information	Vin operating point
30.	Vin p-p	10.667 mV	System Information	Peak-to-peak input voltage
31.	Vout	3.3 V	System Information	Operational Output Voltage
32.	Vout	3.3 V	System Information	Operational Output Voltage
33.	Vout Tolerance	363.64 m%	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
34.	Vout p-p	5.849 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	2.0	Maximum Output Current
VinMax	16.0	Maximum input voltage
VinMin	4.0	Minimum input voltage
Vout	3.3	Output Voltage
base_pn	LMQ644A2-Q1	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature

WEBENCH® Assembly

Component Testing

Some published data on components in datasheets such as Capacitor ESR and Inductor DC resistance is based on conservative values that will guarantee that the components always exceed the specification. For design purposes it is usually better to work with typical values. Since this data is not always available it is a good practice to measure the Capacitance and ESR values of Cin and Cout, and the inductance and DC resistance of L1 before assembly of the board. Any large discrepancies in values should be electrically simulated in WEBENCH to check for instabilities and thermally simulated in WebTHERM to make sure critical temperatures are not exceeded.

Soldering Component to Board

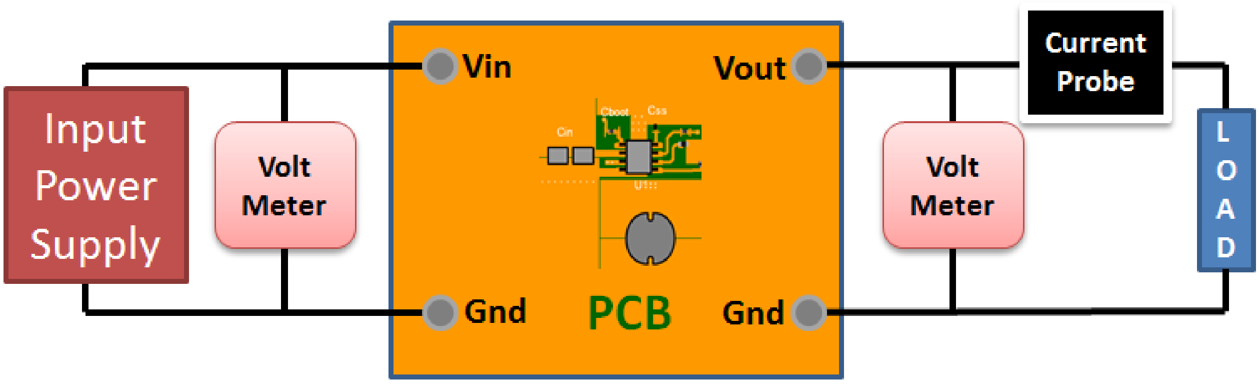
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. To solder the tab town to the board place the iron down on the board while resting against the tab, heating both surfaces simultaneously. Apply light pressure to the top of the plastic case until the solder flows around the part and the part is flush with the PCB. If the solder is not flowing around the board you may need a higher wattage iron (generally 25W to 30W is enough).

Initial Startup of Circuit

It is best to initially power up the board by setting the input supply voltage to the lowest operating input voltage 4.0V and set the input supply's current limit to zero. With the input supply off connect up the input supply to Vin and GND. Connect a digital volt meter and a load if needed to set the minimum Iout of the design from Vout and GND. Turn on the input supply and slowly turn up the current limit on the input supply. If the voltage starts to rise on the input supply continue increasing the input supply current limit while watching the output voltage. If the current increases on the input supply, but the voltage remains near zero, then there may be a short or a component misplaced on the board. Power down the board and visually inspect for solder bridges and recheck the diode and capacitor polarities. Once the power supply circuit is operational then more extensive testing may include full load testing, transient load and line tests to compare with simulation results.

Load Testing

The setup is the same as the initial startup, except that an additional digital voltmeter is connected between Vin and GND, a load is connected between Vout and GND and a current meter is connected in series between Vout and the load. The load must be able to handle at least rated output power + 50% (7.5 watts for this design). Ideally the load is supplied in the form of a variable load test unit. It can also be done in the form of suitably large power resistors. When using an oscilloscope to measure waveforms on the prototype board, the ground leads of the oscilloscope probes should be as short as possible and the area of the loop formed by the ground lead should be kept to a minimum. This will help reduce ground lead inductance and eliminate EMI noise that is not actually present in the circuit.



Design Assistance

1. The LMQ644A2-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application

2. Master key : 27AFC3A06A218B6F8EA41ED3B4C0DDB7[v1]

3. **LMQ644A2-Q1** Product Folder : http://www.ti.com/product/LMQ644A2%2DQ1 : contains the data sheet and other resources.

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